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ON
BI-AXIAL ROTATING MAGNETIC
THERAPEUTIC DEVICE

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BI-AXIAL ROTATING MAGNETIC THERAPEUTIC DEVICE

Cross-References to Related Applications

This patent application is related to United States Provisional Patent Application Serial Number 60/272,384 filed February 28, 2001 entitled "Bi-Axial Rotating Magnetic Therapeutic Device," which application is incorporated herein by this reference thereto.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates generally to a magnetic field generating apparatus and more specifically to a magnetic field generating apparatus that produces a time-varying angular displacement of magnetic flux density for use in therapeutic applications on humans or on animals.

Description of the Related Art

Various devices have been made to create time-varying magnetic fields for use on the human body. Generally, two types of time-varying magnetic fields have been used. The first one used an alternating current ("AC") field that is produced when electric current is caused to alternate at any given frequency. In accordance with Maxwell's equations, a magnetic field is concurrently produced at the same frequency as the electric field. Included in this first type of

time-varying magnetic field device are pulsed electromagnetic fields (PEMF) which are generated when a current is caused to move through a conductor in discrete impulses of electric charge moving in the same direction.

A second general type of device for creating time-varying magnetic field involves physically moving a static magnetic field through space. While linear displacement is one way to accomplish this, another common method involves rotating the static magnetic field. The source of the static magnetic field is generally a permanent magnet, since an electromagnet requires considerable expenditure of energy in the form of current generation and the subsequent dissipation of unwanted heat energy.

The therapeutic uses of time-varying magnetic fields have been described and clinically evaluated in numerous literature. The more popular publications written for the general public include "Magnetic Therapy" by Dr. Ronald Lawrence and Dr. Paul Rosch, "The Pain Relief Breakthrough" by Dr. Julian Whitaker and Brenda Adderly, and "Magnetic Therapy in Eastern Europe" by Dr. Jiri Jerabek and Dr. William Pawluk. These books offer numerous references to clinical studies which purport to show the effectiveness of time-varying magnetic fields for the treatment of a multitude of chronic and acute conditions including atherosclerosis, carpal tunnel syndrome, chronic bronchitis, post-ischemic injury, edema, fractures, infected wounds, limb grafts, burns, scars, macular degeneration, etc. The lack of any substantial negative side effects are also purported for most treatments. In recent years, the general public and even the medical community have increasingly accepted magnetic therapy as an alternative treatment worthy of consideration for such conditions.

Patented devices which utilize permanent magnets to produce a time-varying magnetic field for therapeutic purposes include Horl, U.S. Patent 4,727,857; Kleitz U.S. Patent 5,632,720; and Sounder U.S. Patent 6,001,055. All of these devices function by causing permanent magnets to rotate around a fixed axis. The magnetic field generated by each of these devices sweeps out into space in a single direction. Changing the direction of the rotation requires manual manipulation of the entire device since the axis upon which the magnets rotate is stationary. It has been observed that the angle at which magnetic flux lines cut through tissue can influence the degree of beneficial effects. What is needed therefore is a handheld device or a device capable of being attached a part of the body or to clothing, or the like, that will create a sweeping magnetic field in a multitude of directions, thus providing more complete angular coverage to the part of the body being treated with the moving magnetic field.

SUMMARY OF THE INVENTION

The present invention provides a magnetic field that varies in intensity and/or in polarity by causing a magnet to rotate about two axes at the same time. This is accomplished by rotating a magnet about a first axis and concurrently or intermittently rotating this first axis around a second axis that is oblique from the first axis.

It is an object of the present invention to provide a handheld device for applying a time-varying magnetic field for use on the body of a human or animal. Another object of the present invention is providing a therapeutic device that causes the magnetic field to vary in time in more than one direction.

It is another object of the present invention to provide a device that can be attachable to a part of a body or to clothing for applying a time-varying magnetic field to the body.

These and other objects and advantages of the present invention will be apparent from a review of the following specification and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a top view of one embodiment of the pertinent features of the present invention.

Figure 2 is a front view of one embodiment of the present invention.

Figure 3 is a perspective view of another embodiment of the present invention.

Figure 4 is a perspective view of another embodiment of the present invention.

Figure 5 is a perspective view of a cover of one embodiment of the present invention.

Figure 6 is a perspective view of another embodiment of the present invention.

Figure 7 is a perspective view of another embodiment of the present invention.

Figure 8 is a perspective view of another embodiment of the present invention showing a magnetic unit and a free moving member.

Figure 9 is a perspective view of the embodiment shown in Figure 8 further showing an enclosure assembly **90** and retainer member **92**.

Figure 10 a perspective view of the embodiment shown in Figure 9 from a different angle showing annular rolling surface **78** and pivot member **79**.

Figure 11 is a perspective view of the embodiment Figure 8 further showing a DC motor and right-angle gear box attached to the magnetic unit and a partially disassembled cover for enclosing the invention.

Figure 12 is a perspective view of the embodiment Figure 8 further showing how the component parts fit in cover **94**.

Figure 13 is a perspective view of the embodiment shown in Figure 12 from a different angle.

Figures 14 is a perspective view of a cover **94** for the embodiment shown in Figure 8.

Figures 15 is a perspective view of the cover **94** of the embodiment shown in Figure 14 from a different angle.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

The detailed description set forth below in connection with the appended drawings is intended as a description of presently-preferred embodiments of the invention and is not intended to represent the only forms in which the present invention may be constructed and/or utilized. The description sets forth the functions and the sequence of steps for constructing and operating the invention in connection with the illustrated embodiments. However, it is to be understood that the same or equivalent functions and sequences may be accomplished by different embodiments that are also intended to be encompassed within the spirit and scope of the invention.

The action of the bi-axial rotation is accomplished by mounting a permanent magnet **2** on a rod **4** that has a drive gear **6** or other traction surfaces are attached at one end. Although a gear system is used in the preferred embodiment, other embodiments without the use of gears can be used, such as an o-ring, sprocket, or rubberized surface capable of imposing an angular force on the rod by contact with an external force. The magnet **2**, rod **4** and drive gear **6** assembly is then placed on a rotatable circular track **8**, having either matching gear teeth or

other surface for exerting this external force on the ends of the rod 4. The magnet 2 can be a rectangular or substantially spherical.

In one embodiment, rod is sandwiched between the rotatable circular track 8 and a matching stationary circular track 16, which faces the rotatable circular track 8. A motor 20 is coupled to the rotatable circular track 8 and causes the track to rotate. The angular force imparted on drive gear 6 causes rod 4 to turn with track 8. Since the drive gear 6 is engaged with the surfaces of both circular tracks 8 and 16, drive gear 6 is forced to roll at the same time it moves along the circular tracks. The drive gear 6 causes rod 4 to roll like an axle in a direction perpendicular to the direction of the rotation of rod 4 around the circular tracks 8 and 16. The magnet 2 is thereby caused to move in both a primary rotational movement and a secondary rotational movement, both turning and rolling the magnet 2. As a result, this configuration creates a complex bi-axial sweeping action of the magnetic field. As shown in Figure 1, a placeholder or floating gear 6' is placed on the end of rod 4 opposite drive gear 6 for balance and stability purposes. Floating gear 6' is rotatably mounted to rod 4 so that this gear 6' does not impart a rolling force on rod 4, and only the drive gear 6 causes rod 4 to roll.

In particular, one embodiment of the present invention is shown in Figures 1 and 2. Figure 1 illustrates the embodiment from a top view showing the stationary gear track 16, gear teeth 10, magnetic unit 2, the ends of rod 4, drive gear 6, and floating gear 6'. Figure 2 shows the embodiment from a side view further showing free moving gear ring 8 and motor 20. (In Figure 1, the free moving gear ring 8 and motor 20 have been removed for purposes of illustration of the gears 6 and 6' and stationary gear track 16.) As shown in Figure 1, a magnetic unit 2 is mounted to a rod 4. Although the magnetic unit 2 shown in this

embodiment is spherical in shape, other shaped magnets can be used such as a bar magnet, a sheet magnet having a pre-determined magnetic pattern, or the like. Additionally, although the embodiment illustrated shows rod 4 extending through magnetic unit 2, rod 4 may alternatively attach to one side or end of magnetic unit 2.

One end of the rod 4 contains a drive gear 6 that rides between a stationary gear ring 16 and free moving gear ring 8. The other end of rod 4 contains floating gear 6' which likewise rides between a stationary gears ring 16 and free moving gear ring 8. Preferably, the stationary gear ring 16 and the free moving gear ring 8 are made from a generally non-magnetic material so as not to interfere with the magnetic field produced by the magnetic unit 2. The free moving gear ring 8 has gear teeth 9 on a first surface 12 and gear teeth 11 on a second surface 14. Motor 20 drives gear 18, which in turn engages gear teeth 9 of the first surface 12 of ring 8, either directly or indirectly. Accordingly, as the gear 18 turns, it drives the free moving gear ring 8.

As the free moving gear ring 8 turns, the rod 4 is forced to turn, creating a primary rotational movement of the magnetic unit 2 because gears 6 and 6' are engaged with the gear teeth 11 on the second surface 14 of the free moving gear ring 8. End gears 6, however, also engage the teeth 10 on the surface of stationary ring 16. While one of floating gear 6' is rotatably mounted to rod 4, and thereby does not impart a rolling force on rod 4, drive gear 6 fixed to rod 4. As a result, when drive gear 6 is forced to roll as it rotates along free moving gear ring 8, rod 4 is forced to likewise roll about this second axis. Hence, a bi-axial rotation of magnetic unit 2 is produced, creating a complex bi-axial sweeping action of the magnetic field. With this design, only a single magnet 2 is necessary to produce this complex time-

varying magnetic field. The entire embodiment can be housed inside a plastic housing (e.g., see Figures 5 and 11 through 15) allowing the spherical magnetic unit **2** to rotate freely about two separate axes. The present invention can be positioned or moved by hand over a desired region of the human body, or it can be attached to a part of the user's body or clothing.

5 In another embodiment a magnet assembly comprises a free moving member **30** having one or more extensions surrounding a magnetic unit **22**. A rod **24** is mounted to the magnetic unit **22**. The two ends of the rod **24** extend beyond the free moving member **30**. A rolling member **26** is fixed to one end of rod **24**. (Optionally, a slipping member may be rotatably mounted to the opposite end of rod **24**, it has been found that, given sufficient precision of component parts, and minimization of the tolerances involved, a second floating or slipping member is not necessary.) This embodiment includes a cover **52** that surrounds the magnet assembly and has an inner surface which defines a circumferential groove for houses the rolling member **26**, and which defines one or more pivot members **79** for pivotally retaining the magnet assembly. The rod **24**, the rolling member **26**, the free moving member **30**, and the cover **52** are all preferably made of substantially non-magnetic materials.

15 A motor **42** or the like is coupled to an extension **36** on the free moving member **30**, either directly or indirectly using a drive belt, gear box, or the like. The turning of the motor **42** then causes the magnet assembly to rotate. As the magnet assembly rotates, the rolling member and the slipping member are forced to roll due to contact with an annular surface **28** of the circumferential groove formed in the inner surface of the cover **52**. This rolling action of the rolling member causes the magnetic unit **22** to roll. Thus, the magnetic unit **22** both rotates about one axis and rolls about another, producing a time-varying field of magnetic flux density

and a time-varying field of angular flux displacement for use in connection with humans or animals for therapeutic purposes.

One example of this embodiment is shown in Figure 3. As in the prior embodiment, the magnetic unit 22 is mounted to a rod 24. One end of the rod 24 has a rolling member 26 which is in contact with the annular surface 28. Surface 28 may be formed in the cover as described above and surrounds the magnetic unit 22. In Figure 3, the rest of the cover has been removed so that only surface 28 is shown in the illustration. Surface 28 can also be a stationary ring with sufficient surface traction to exert an angular force on rolling member 26. The rolling member 26 and/or surface 28 would preferably consist of an elastomeric material or other material with sufficient gripping properties. Also, surrounding the spherical magnetic unit 22 is a free moving member 30, which is radially inside and oblique to surface 28. The rod 24 rotatably extends through openings 25 in the free moving member 30. As a result, when the rolling member 26 rotates along the surface 28, so does the free moving member 30, but the rolling action of the rolling member 26 does not cause the free moving member 30 to likewise roll.

On each of the first half 32 and the second half 34 of free moving member 30 there exists an extension 36 that is pivotally mounted to a casing or cover 52. An example of such a cover is shown in Figure 5, and an example of a pivot member 28 for pivotally mounting the free moving member 30 within the cover 52 is shown in Figure 10. Attached to the extension 36 on the first half 32 of the free moving ring 30 is a drive belt 38. In this embodiment, the drive belt 38 is a rubberized belt, but can be any material with similar properties, such as a toothed belt, chain, or the like. The drive belt 38 also attaches to a rotatable unit 40 that

attaches to a motor **42**. Motor **42** can be a single speed motor or a motor having varying speed capabilities.

Thus, motor **42** along with rotatable unit **40** constitutes a primary rotational means which causes magnetic unit **22** and free moving member **30** to rotate about one axis. While the free moving member **30** rotates, not only does the magnetic unit **22** rotate according to this primary rotation means, but also according to the secondary rotation means created by the interaction of rolling member **26** and annular rolling surface **28**.

Figure 4 represents yet another embodiment of the present invention. In this embodiment, a motor **43** is directly connected to the extension **46**, with no need for a drive belt. A motor **43** turns the extension **46** directly, causing the free moving member **50** to rotate and having the same effect on the other parts in this embodiment as in the prior-disclosed embodiment.

Figure 5 represents one type of cover **52** that may be used in conjunction with the presently preferred embodiments of the present invention. The cover **52** contains an power switch **56** connected to the motor (not shown). In the preferred embodiments, the cover is made of plastic, but can be made of other materials with similar generally non-magnetic properties. However, this invention can function independently without the use of the cover, or with the use of a partially transparent cover, such as window **54**, so as to show the user the complex movement of the internal magnetic unit **22**.

While Figures 1 and 2 illustrate one embodiment of the present invention in which gear teeth **9** and gear teeth **11** are on opposing surfaces of gear **8**, other embodiments are equally contemplated by the present invention. For example, in Figure 6, a motor **64** is in

communication with the radially external surface of rotatable gear 68. As shown in Figure 6, motor 64 causes drive belt 60 to turn gear 68, which in turn causes magnetic unit 62 to likewise turn. Magnetic unit 62 rotates as it turns because rotatable end means 66 is sandwiched between rotatable gear 68 and a fixed gear as described previously with respect to Figure 2. The fixed gear is removed from view in Figure 6 for purposes of clarity of the illustration. This fixed gear in combination with rotatable gear 68 causes rotatable end means 66 to rotate. As a result, magnetic unit 62, as just as in Figures 1 and 2, rotates about two axes.

Figure 6 illustrates an embodiment in which motor 64 is in communication with gear 68 indirectly, utilizing a drive belt 60. The drive belt shown is a rubberized drive belt, but could just as easily be a toothed belt, a chain, or the like, provided that the radially external surface of rotatable gear 68 comprises a matching gear, sprocket, or other friction features so that an angular force is exerted in the rotatable gear 68. Alternatively, motor 64 could be positioned so as to directly communicate with the radially external surface of gear 68 by way of an orthogonal or beveled gear and tooth configuration, or other combination of gripping surfaces as shown in Figure 7. The result in each instance is the same; magnetic unit 62 is caused to rotate in two axes at the same time thereby causing a complex bi-axial sweeping motion of the magnetic field emanating therefrom.

Another embodiment is shown in Figures 8 through 15. Like in the embodiments of Figures 3, a motor 74 (shown in Figure 10) exerts an angular force on magnetic unit 72 while annular rolling surface 78 remains fixed relative to cover 52. As a result, the magnetic unit 72 fixed to an end rolling member 76, as described in detail above with respect to rolling member

26, is forced to both rotate about a primary axis and at the same time roll about a secondary axis. In contrast to Figure 3, the axis of rotation of the motor is perpendicular to the primary axis of rotation of the magnet assembly.

More particularly, the magnetic unit 72 is housed inside a free moving member 80 comprising a first half 81 and a second half 83. When mating surfaces 82 and 84 of the first and second halves of the free moving member 80, the inner surface of the free moving member 80 defines an approximately spherical chamber in which the magnetic unit 72 is held. With magnetic unit 72 placed in the chamber, mating surfaces 82 and 84 are then welded together at a sufficient number of places along to withstand the sort of impacts that are common to home appliances, such as being dropped during use, etc.

Mating surfaces 82 and 84 also define one or more clearances 87. When mating surfaces 82 and 84 are welded together, these clearances 87 define openings 88. The magnetic unit 72 further comprises two protruding arms 73 which extend away from magnetic unit 72 in diametrically opposite directions and extend through and beyond two openings 88. The present invention equally contemplates a magnetic unit 72 having only a single protruding arm 73 provided the magnetic unit 72 remains sufficiently stable and free to rotate about an axis defined by the elongate length of said protruding arm 73. The chamber defined by the internal surfaces of the free moving member 80 and the openings 88 defined by the clearances 87 formed in mating surfaces 82 and 84 are both large enough to loosely retain magnetic unit 72 and protruding arms 73, respectively. Thus, while magnetic unit 72 is substantially enclosed within the free moving member 80, the magnetic unit 72 is capable of freely rotating

relative to the free moving member **80** about the axis of rotation defined by the one or two protruding arms **73**.

The free moving member **80** is held in an enclosure assembly **90**. The enclosure assembly **90** comprises an inner surface **91** which defines an approximately spherical chamber, an annular rolling surface **78** formed in inner surface **91**, and a pivot member **79** disposed in the inner surface **91**. Also, a portion of the inner surface **91** functions as a wave washer retaining surface, as discussed further below. The enclosure assembly **90** is preferably fixed relative to the cover **52** and thus may be mounted to the cover or integrally formed in the inner surface of the cover **52**. In either case, the clearance between the outer surface of the free moving member **80** and the inner surface **91** of the enclosure assembly **90** so that it may rotate about a pivot structure **86** which is formed in the first half **81** of free moving member **80** and which pivotally engages pivot member **79**. Figure 10 illustrates an embodiment that utilizes a bearing pin as pivot member **79**. This function of pivotally mounting the free moving member **80** inside the enclosure assembly **90** may likewise be accomplished by other engaging structures, such as a circular recess formed in the enclosure coupled with a point formed at the apex of the first half **81** of the free moving member **80**.

As mentioned above, in a preferred embodiment, the rotation of motor **74** is perpendicular to the desired rotation of the free moving member **80**. The rotary motion of motor **74** is translated by a standard right-angle gear box **75**, which comprises two mating angled gears or the like. At the same time, the speed of the motor may also be stepped up or down, which will inversely effect the torque of the imparted rotary motion. Presently, the best made involves a direct current or "DC" motor connected to a right-angle step-down gear box

75 for producing a ten-fold increase in torque. The DC motor is powered by a rechargeable battery 70 housed in battery case 70' or directly from a AC/DC power converter 71 through plug-in jack 71', which may also operate as a battery recharger as is common in home appliances.

5 The resultant rotary force of the motor, once translated 90° and stepped down by the gear box 75, drives free moving member 80 much the same way as illustrated in and discussed with respect to Figure 4, above. The driving shaft (not shown) extends through axial opening 89 and directly imparts an angular force on drive extension 85 located at the apex of the second half 83 of free moving member 80.

10 The end of one of the protruding arms 73 is equipped with rolling member 76. As free moving member 80 rotates, rolling member 76 is dragged along the annular rolling surface 78. Annular rolling surface 78 imparts an angular force on rolling member 76 as the latter moves along the annular rolling surface 78. A retainer member 92 is placed between the inner surface 91 of the enclosure assembly 90 and free moving member 80 to exert a downward axial force on free moving member 80. While the retainer member illustrated in Figure 9 is a spring washer or wave-type washer, other means are equally contemplated for exerting an axial force on free moving member 80, such as a leaf spring, compression spring, diaphragm, or the like. This insures that a sufficient amount of contact occurs between rolling member 76 and annular rolling surface 78 to create this angular force on rolling member 76. As a result, rolling member 76 is forced to roll about the axis of its elongate dimension. A slipping member may be utilized in the opposite projecting arm 73, as described above in relation to

Figures 3 and 4. With sufficiently tight tolerances between the magnet assembly and the enclosure assembly, however, a slipping member can be made to be unnecessary.

It is believed to be additionally advantageous to provide the operator with a visual means to realize the great degree of complex bi-axial movements that magnetic unit 72 is forced to make by this configuration. In Figure 8, the first half 81 of free moving member 80 is shown as having large openings. This allows the complex movements of the magnetic unit 72 to be visible from outside the free moving member 80. It is equally contemplated that a transparent or semi-transparent material could be used to accomplish similar advantageous results. Similarly, the lower half 93 of the enclosure assembly 90 in Figure 9 may be made from a transparent or semi-transparent material, or be formed with relatively large openings as with first half 81. A window or lens 96, as shown in Figures 11 through 14, may form a part of cover 94.

In addition to the window or lens 96, the configuration shown in Figures 11, 12, and 13 provide a particularly efficient packaging of the present invention. The two halves of the cover 94 are plastic and molded to fit together and capture the window or lens 96, the power switch 98, the motor 74 and gear box 75, the battery case 70', DC plug-in jack 71', and the enclosure assembly 90. That is, essentially every component of the product is captured in one of the molded cover halves, the other half therefore being capable of removal without disrupting the arrangement of the components of the invention and product. Figures 12 and 13 show from the top and bottom, respectively, the efficient packing of the essential and auxiliary components for the present invention in the embodiment shown. Figures 14 and 15 show from the bottom and top, respectively, another cover contemplated by this invention. The

power/recharge cord is detachable from the product and is not necessary for proper operation of the present invention, as the motor can run on batteries **70** as shown in Figure 13.

Again, as mentioned above, all components other than the magnet unit are preferably made out of material that will not negatively affect the magnetic flux emanating from the magnetic unit **72**. Instead, it is presently believed that the proper selection of materials for the enclosure assembly may be able to positively affect the magnetic flux by concentrating the magnetic energy and refocusing it towards the body part being treated.

While the present invention has been described with regards to particular embodiments, it is recognized that additional variations of the present invention may be devised without departing from the inventive concept.